ROADWAY SAFETY INSTITUTE

Human-centered solutions to advance roadway safety

Overview of the USDOT Connected Vehicle Technology and Applications

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Outline

- Transportation Challenges
- Connected Vehicle (CV)
- CV Technology for Safety
- Conceptual Relationship of CV Applications
- Safety and Mobility Applications
- Closing Remarks

Today's Transportation Challenges

Safety

- ✓ 33,561 highway deaths in 2012
- ✓ 2.36 million people were injured in motor vehicle traffic crashes

Mobility

- ✓ 5.5 billion hours of travel delay
- ✓ $121 billion cost of urban congestion

Environment

- ✓ 2.9 billion gallons of wasted fuel
- ✓ 56 billion lbs of additional CO_2

Data Sources: *FARS 2012 Data,* National Highway Traffic Safety Administration; *2012 Annual Urban Mobility Report*, Texas Transportation Institute

Connected Vehicle: 15+ years in the making

Research of technologies and applications that use wireless communications to provide connectivity:

- Among vehicles of all types
- Between vehicles and roadway infrastructure
- Among vehicles, infrastructure and wireless consumer devices

FCC allocated 5.9 GHz (75 MHz band) spectrum – Dedicated Short Range Communications (DSRC) for transportation safety on Oct. 21, 1999

- Low latency, line of sight
- High bandwidth, 300~500m range
- Now an established standard, IEEE 802.11p & SAEJ2735 (Wireless Access in Vehicular Environments – WAVE)

Background and Terminology

- **High speed, low latency wireless communication** of **vehicle position** is a critical element of the CV program.
- Many safety and traffic operations applications based on **vehicle-to-vehicle (V2V)** and **vehicle-to-infrastructure (V2I)** communication have been in development for some time.
- In order for many of these safety applications to work, the system's position accuracy must be sufficient to **locate each vehicle within a lane.**
- Standards for on-board vehicle-to-vehicle (V2V) safety communications systems have already been developed. These systems must be capable of transmitting the SAE J2735 defined **Basic Safety Message** (BSM).

Technology for Safety – 5.9 GHz DSRC

What it is

- Wi-Fi radio adapted for vehicle environment
- Inexpensive to produce in quantity
- Original FCC spectrum allocation in 1999
- FCC revised allocation in 2004 and 2006

How the technology works

- Messages transmitted 10 times/sec (line of sight)
- Basic Safety Message (BSM): vehicle position, speed, heading, acceleration, size, brake system status, etc.
- Privacy is protected (vehicle location is **NOT** recorded or tracked)

Benefits of DSRC technology compared to radar/laser technology

- Reduced price
- Improved reliability → fewer false alarms
- Increased performance → addresses more crash scenarios

Drawback of the technology

- Both vehicles need to be equipped to gain benefit
- Requires security infrastructure

Fully Connected Vehicle

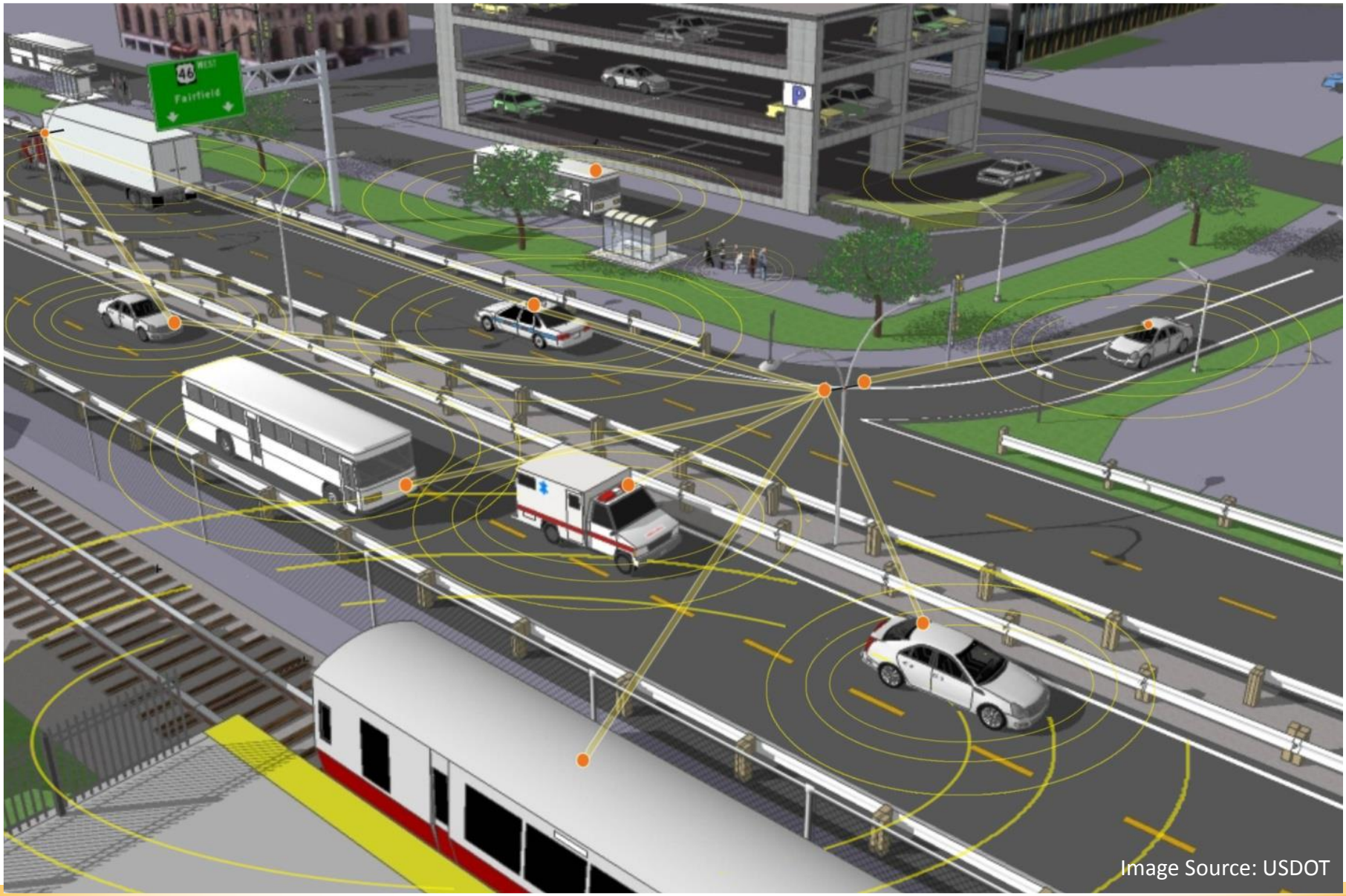


Image Source: USDOT

Scope of the Connected Vehicle

Applications

- Safety – V2V, V2I, or V2X (pedestrians, bikes, or others)
- Mobility – Signal control, flow optimization, emergency response, transit, freight, etc.
- Environment – Real-time road weather

Communications Protocols

- Cellular – Diagnostics and communications
- Wi-Fi – Information and entertainment
- DSRC – Safety communications
- Near Field, Bluetooth, Zigbee, etc.

Devices

- Integrated – Built in or aftermarket
- Carry-in – Carried in by driver/passenger
- Mobile – Smartphone or others
- Roadside equipment (RSE)

Potential Benefit of the Connected Vehicle

- Increases in safety, mobility, system efficiency, and access to resources for disadvantaged groups
- Decreases in negative environmental impacts such as vehicle emissions, the need for physical expansion, and noise
- Decreases in undesirable transportation impacts to the environment and society
- Increased opportunities to partner with non-government groups, such as private industry and universities
- Real-time and real-world data to help with transportation planning and transportation system operations
- Reduction of fatalities through weather-related, safety, infrastructure-based, and other applications

Connected Vehicle (CV) Applications

V2I Safety

- Red Light Violation Warning
- Curve Speed Warning
- Stop Sign Gap Assist
- Spot Weather Impact Warning
- Reduced Speed/Work Zone Warning
- Pedestrian in Signalized Crosswalk Warning (Transit)

V2V Safety

- Emergency Electronic Brake Lights (EEBL)
- Forward Collision Warning (FCW)
- Intersection Movement Assist (IMA)
- Left Turn Assist (LTA)
- Blind Spot/Lane Change Warning (BSW/LCW)
- Do Not Pass Warning (DNPW)
- Vehicle Turning Right in Front of Bus Warning (Transit)

Road Weather

- Motorist Advisories and Warnings (MAW)
- Enhanced MDSS
- Vehicle Data Translator (VDT)
- Weather Response Traffic Information (WxTINFO)

Environment

- Eco-Approach and Departure at Signalized Intersections
- Eco-Traffic Signal Timing
- Eco-Traffic Signal Priority
- Connected Eco-Driving
- Wireless Inductive/Resonance Charging
- Eco-Lanes Management
- Eco-Speed Harmonization
- Eco-Cooperative Adaptive Cruise Control
- Eco-Traveler Information
- Eco-Ramp Metering
- Low Emissions Zone Management
- AFV Charging / Fueling Information
- Eco-Smart Parking
- Dynamic Eco-Routing (light vehicle, transit, freight)
- Eco-ICM Decision Support System

Agency Data

- Probe-based Pavement Maintenance
- Probe-enabled Traffic Monitoring
- Vehicle Classification-based Traffic Studies
- CV-enabled Turning Movement & Intersection Analysis
- CV-enabled Origin-Destination Studies
- Work Zone Traveler Information

Mobility

- Advanced Traveler Information System
- Intelligent Traffic Signal System (I-SIG)
- Signal Priority (transit, freight)
- Mobile Accessible Pedestrian Signal System (PED-SIG)
- Emergency Vehicle Preemption (PREEMPT)
- Dynamic Speed Harmonization (SPD-HARM)
- Queue Warning (Q-WARN)
- Cooperative Adaptive Cruise Control (CACC)
- Incident Scene Pre-Arrival Staging Guidance for Emergency Responders (RESP-STG)
- Incident Scene Work Zone Alerts for Drivers and Workers (INC-ZONE)
- Emergency Communications and Evacuation (EVAC)
- Connection Protection (T-CONNECT)
- Dynamic Transit Operations (T-DISP)
- Dynamic Ridesharing (D-RIDE)
- Freight-Specific Dynamic Travel Planning and Performance
- Drayage Optimization

Smart Roadside

- Wireless Inspection
- Smart Truck Parking

Source: USDOT

Connected Vehicle Safety Applications

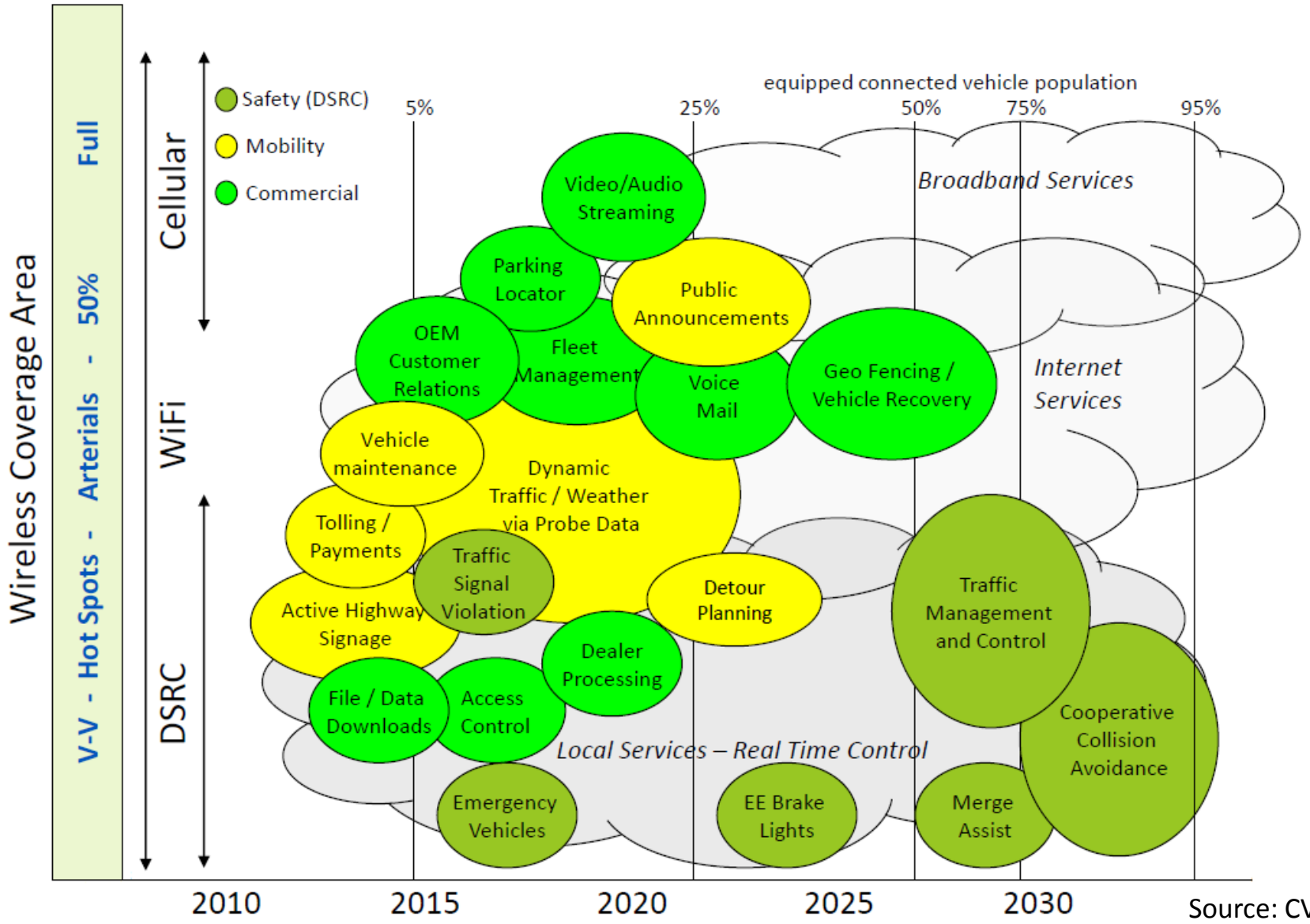
V2V

- Forward Collision Warning (FCW)
- Emergency Electronic Brake Light (EEBL)
- Blind Spot/Lane Change Warning (BSW/LCW)
- Do Not Pass Warning (DNPW)
- Intersection Movement Assist (IMA)
- Left Turn Assist (LTA)

V2I

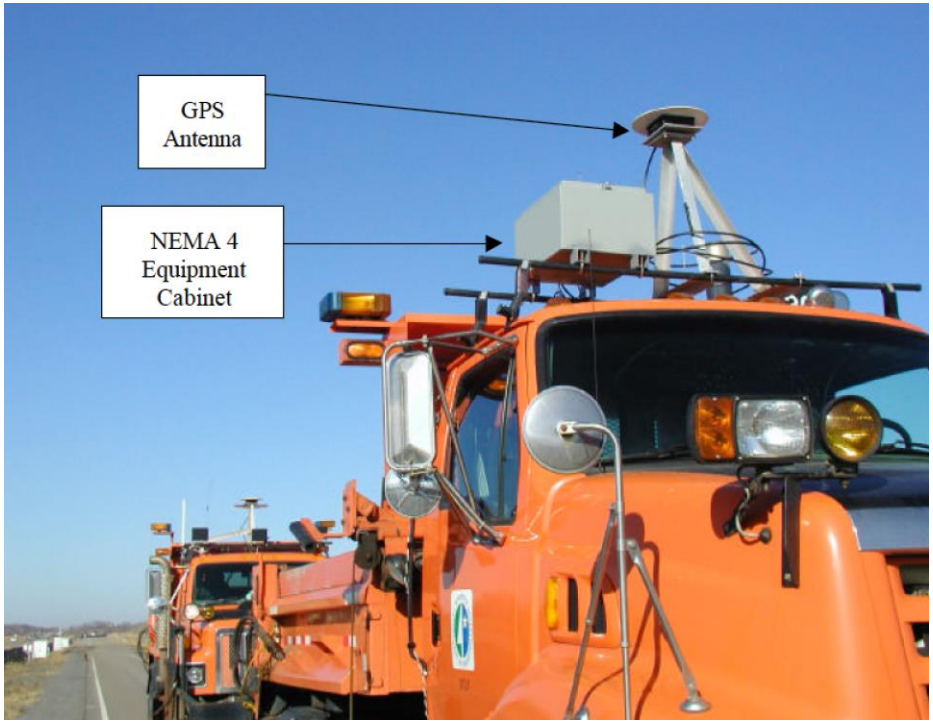
- Curve Speed Warning (CSW)
- Red Light Violation Warning (RLVW)
- Spot Weather Information Warning (SWIW)
- Reduced Speed Zone Warning (RSZW)
- Stop Sign Gap Assist (SSGA)
- Smart Roadside
- Transit Pedestrian Warning

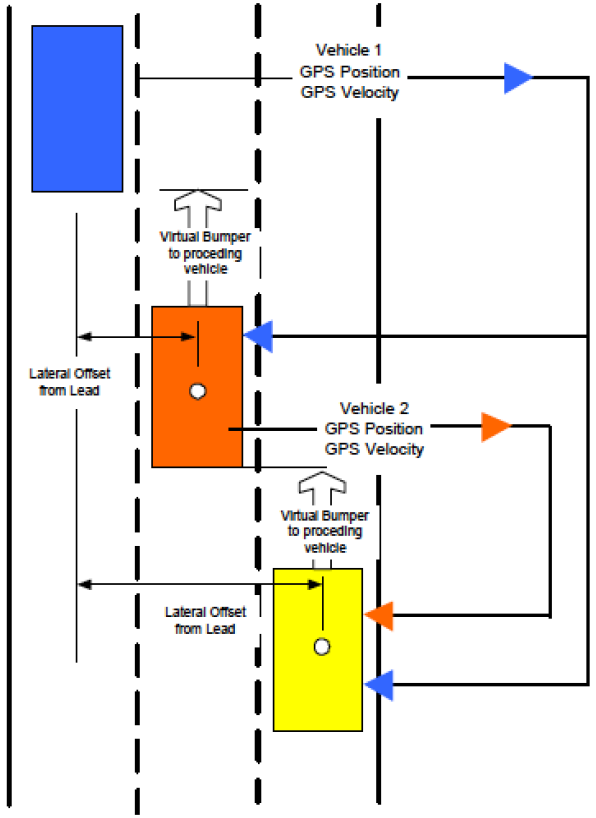
Conceptual Relationships of CV Applications



Source: CVTA, 2013

V2V: Multi-vehicle Gang plowing (2005)





Architecture of multi-vehicle gang plow system. Each plow is equipped with DGPS and a wireless communication transceiver. Each vehicle is identified by its position in the gang. Each vehicle broadcasts its position and speed to every vehicle behind it in the formation.

(Figure 3.1 & 4.1 from "DGPS-Based Gang Plowing," MnDOT report MN/RC – 2005-18, 2005)

Mobile Accessible Pedestrian Signal (MAPS)

Using Wi-Fi / Cellular

Bluetooth

SPaT
SSM

Cellular

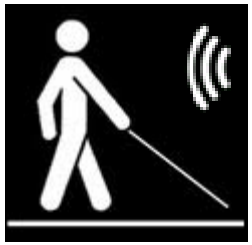
Digital Map

Geometry and
Warning Info.

MAPS User Interface

Geometry Information

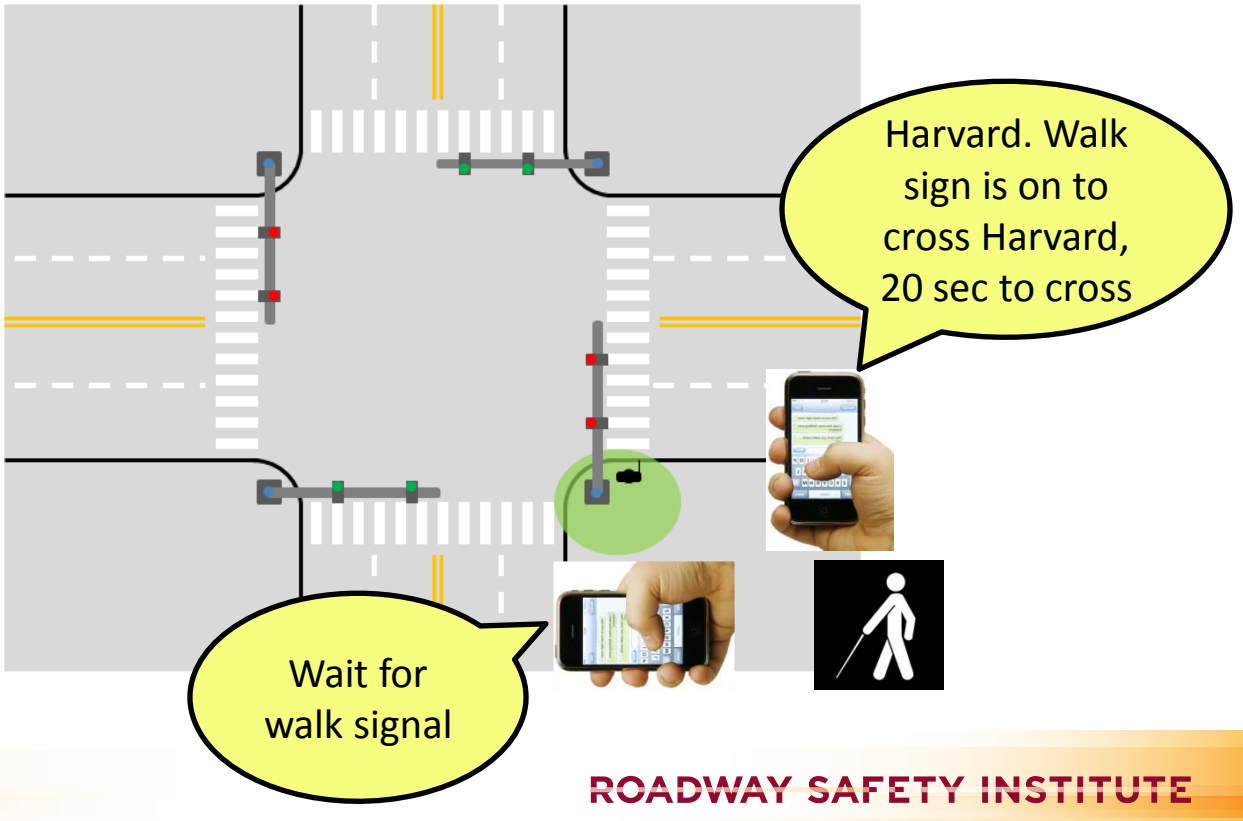
- Single tap for orientation and geometry information
- Text-to-Speech message



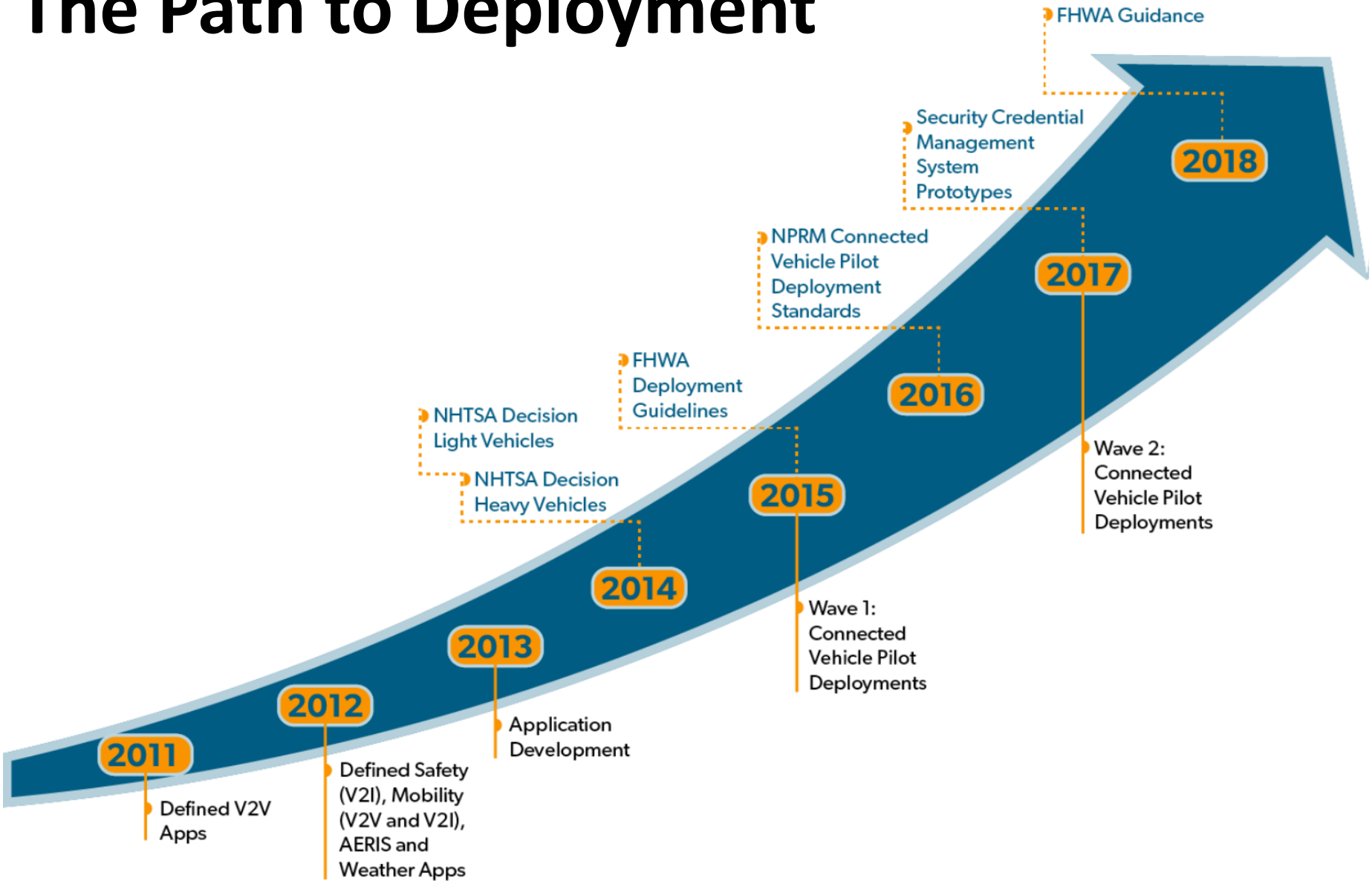
MAPS User Interface

Signal Information

- Double tap to confirm crossing
- Send walk phase request to traffic signal controller
- Obtain signal timing information
- Vibrate and announce signal info when walk phase is on. No sec. by sec. countdown update.



The Path to Deployment



Source: *USDOT*

THANK YOU !

QUESTIONS ?